

MEMO

To: Steve Hall
Jones and Stokes

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Project No. T-4169-1

From: Chuck Lie
Terra Associates, Inc.

Subject: Technical Memorandum
Environmental Soil Sampling
Arsenic, Cadmium, and Lead
Lone Star Maury Island Site
King County, Washington

Steve:

As requested, we have performed environmental sampling on the Lone Star Maury Island Site in King County, Washington. The purpose of the sampling was to obtain additional information regarding the distribution of arsenic, cadmium, and lead in the site soils. For comparison purposes, we have included the summaries of soils testing done on the Lone Star Site by others. The data generated by others is shown for informational purposes only.

Information reviewed by Terra Associates indicates that the source of the arsenic, cadmium, and lead present on the site is the aerial fallout from the former ASARCO copper smelter in Ruston, approximately five air miles south of the site. The other typical source for arsenic contamination of surficial soils in Washington State is the use of arsenic-containing pesticides used earlier in this century. The use of arsenic-containing pesticides was typically limited to agricultural areas, including orchards. There is no indication that this site was a former agricultural area.

We evaluated possible impacts due to the presence of these heavy metals, along with possible mitigation that could be used in the proposed mining activities on the site. A discussion of regulations that typically covers issues relating to arsenic releases into the environment is also presented in this memo.

Executive Summary

The results of site soil sampling and testing is consistent with prior sampling on-site. A total of 80 soil samples were taken as part of this study. Sixty of the samples were in the near-surface soils, within 18 inches of the ground surface. Twenty of the soil samples were taken at depth of greater than eight feet below the existing grades. Elevated heavy metals associated with the ASARCO plume of aerial contamination is present in the topsoils on the site. The levels are the greatest in the upper 12 inches. The underlying soils proposed for export from the site during gravel pit operations have levels of heavy metals well within the naturally occurring levels of the metals in Puget Sound area soils.

The results of our review of existing data, and of leach tests on actual samples obtained in this study, indicate that the metals have a low solubility. No evidence of groundwater impacts due to the presence of the heavy metals has been documented on the site or in the area of the site.

The proponent, Lone Star Industries, is currently discussing the site conditions with the Washington Department of Ecology. The presence of the elevated metals can be mitigated as part of the gravel pit operation plan. Additional sampling of the affected soils is expected to be performed during site development work to verify that the affected soils have been properly segregated for appropriate management.

Prior Testing/Pathways Study

Prior testing on Vashon Island is summarized in the *Ruston/Vashon Arsenic Exposure Pathways Study* (the Pathways Study) performed in 1987. The Pathways Study was conducted by the School of Public Health and Community Medicine at the University of Washington, under contract to Ecology. The purpose of the Pathways Study was to determine the health impacts due to the aerial fallout of arsenic from the Ruston smelter.

As part of the Pathways Study, soil samples were taken at selected areas of South Vashon and Maury Island. The soil samples were taken from the upper inch of the soil column. No plot plan with specific soil sample locations is presented in the Pathways Study. It can be assumed that the samples were taken in close proximity to the individuals, families, and houses being monitored for arsenic as part of the study. Thus, the areas on Vashon and Maury Island where soil samples would have been taken would likely have been developed areas with significant cultural development, including lawns and other high use areas where a significant amount of disturbance to the soil column would be expected.

The results of the Pathways Study indicate that on Vashon/Maury Island, the levels of arsenic were in the range of 2 to 290 parts per million (ppm). There were 34 samples in the Pathways Study. The median level was 18.5 ppm, the mean level was 29.6 ppm, and the standard deviation is reported as being 48.5.

The results of testing in the Ruston-North Tacoma area by the Pathways Study found surface soil arsenic levels to be in the range of 0 to 2,069 ppm. Median levels of surface soil arsenic levels in the Ruston-North Tacoma Study areas ranged from 40 to 215 ppm. The Ruston-North Tacoma area is the residential area adjacent to the ASARCO smelter. The results of subsequent testing by the Environmental Protection Agency (EPA) during the cleanup of the Ruston-North Tacoma Study area are generally consistent with the results of soil arsenic testing for the Pathways Study.

No sampling appears to have been done on the Lone Star Site for the Pathways Study.

Prior Testing/Associated Earth Sciences, Inc.

Associated Earth Sciences, Inc. (AESI) performed limited testing of selected samples obtained from geotechnical explorations on the Lone Star Site in 1998. The locations of these samples are shown on Figure 2.

The results of the testing are summarized below.

Table 1
Analytical Test Results
AESI 1998 Samples

Location	Depth	Arsenic (ppm)	Mercury (ppm)	Lead (ppm)
EP-2	8-10 inches (topsoil)	85	0.12	18
EP-2	7 feet	5.7	<0.02	8.5
EP-3	8-10 inches (topsoil)	5.8	0.04	12
EP-9	8-10 inches (topsoil)	5.1	<0.02	9
EP-9	9 feet	<2.3	<0.02	7.1
EP-11	8-10 inches (topsoil)	4.2	0.07	7.6
OBW-1	55 feet	<3	<0.02	7.7
OBW-1	190 feet	<1.7	<0.02	6.0
OBW-2	140 feet	<3	<0.02	8.9
OBW-2	220 feet	<3	<0.02	5.3
MTCA Method A Industrial Sites		200	1	1000

In their report dated March 27, 1998, and revised April 27, 1998, AESI recognized that elevated heavy metals were in the topsoils. The report concludes with the recommendation that additional testing be done, and that the topsoil would require additional management during site operations.

Prior Testing/Vashon Community Council

On the Lone Star Site, field sampling and analytical testing was performed for the Vashon Community Council by Landau Associates and their subcontracted laboratory, Analytical Resources, in December 1998. AGRA, a consultant for Lone Star, was present at the time of the field sampling and obtained field splits of the samples for testing at the laboratory of North Creek Analytical. This testing was limited to surface samples for arsenic only. The locations of the test results are presented on Figure 3.

The test results are as follows in Table 2. The Relative Percent Difference (RPD) is shown for each pair of test results. The RPD is a measure of the precision of testing and is used on duplicate or field replicate samples. The common goal is for the RPD to be 20 percent or less. Some work plans allow RPDs of 35 percent or higher.

Table 2
Surface Soil Arsenic Analysis
AGRA and Landau Samples

Sample	AGRA	Landau	RPD (%)
GM-1	163	199	19.9
GM-2	358	379	5.70
GM-3	179	222	21.45
GM-4	81.6	67	19.65
GM-5	22.9	28	20.04
GM-6	54.4	81	39.29
GM-7	63.1	293	129.12
GM-8	477	357	28.78
GM-9	6.59	9	30.92
GM-10	128	130	1.55

Notes: All units are parts per million (ppm)
$$RPD = 100 [(X_1 - X_2) / \{(X_1 + X_2) / 2\}]$$

As can be seen, half of the RPDs are within the standard range of 20 percent or less. Only 2 RPDs exceed the upper common bound of 35 or less. The variations seen in the test results between the AGRA and Landau samples are most likely a result of variations in the sample matrix and the possible inclusion of some coarser gravel-sized particles in the AGRA samples. The samples taken by AGRA were not sieved to remove particles larger than two millimeters, as required by standard test methods. While the specific values are not identical, the variations in the arsenic values are within common ranges observed for field duplicates.

Current Testing/Terra Associates

Terra Associates has performed two sets of soil sampling and laboratory analysis for arsenic, cadmium, and lead on the Lone Star Site.

Resource Samples

The first set of samples was taken to determine the probable levels of these three metals in the sand and gravel that will be exported from the site. Twenty samples were obtained of materials that would be considered resource materials. Appendix A discusses the field sampling plan.

The results of the testing are as shown in the following table.

Table 3
Analytical Test Results
Resource Samples

Sample Designation	Sample Location	Arsenic (ppm)	Cadmium (ppm)	Lead (ppm)
EP-15 @ 9	Exploration Pit EP-15, nine feet below ground surface, sample of sand beneath surficial till soils.	4.3	0.58U	5.8U
EP-16 @ 10	Exploration Pit EP-16, ten feet below ground surface, sample of sand beneath surficial till soils.	4.5	0.54U	5.4U
EP-17 @ 8.5	Exploration Pit EP-17, ten feet below ground surface, sample of sand beneath surficial till soils.	2.7	0.61U	6.1U
EP-18 @ 10	Exploration Pit EP-18, ten feet below ground surface, sample of sand beneath surficial till soils.	2.4	0.53U	5.3U
EP-19 @ 10	Exploration Pit EP-19, ten feet below ground surface, sample of sand beneath surficial till soils.	3.9	0.54U	5.4U
EP-20 @ 10	Exploration Pit EP-20, ten feet below ground surface, sample of sand beneath surficial till soils.	2.4	0.54U	5.4U
EP-21 @ 10	Exploration Pit EP-21, ten feet below ground surface, sample of sand beneath surficial till soils.	3.5	0.54U	5.4U
EP-22 @ 10	Exploration Pit EP-22, ten feet below ground surface, sample of sand beneath surficial till soils.	3.1	0.54U	5.4U

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Table 3 (Continued)
Analytical Test Results
Resource Samples

Sample Designation	Sample Location	Arsenic ppm	Cadmium ppm	Lead ppm
EP-23 @ 10	Exploration Pit EP-23, ten feet below ground surface, sample of sand beneath surficial till soils.	4.6	0.54U	5.4U
EP-24 @ 10	Exploration Pit EP-24, ten feet below ground surface, sample of sand beneath surficial till soils.	6.9	0.58U	5.8U
EP-25 @ 10	Exploration Pit EP-25, ten feet below ground surface, sample of sand beneath surficial till soils.	3.1	0.54U	5.4U
EP-26 @ 10	Exploration Pit EP-26, ten feet below ground surface, sample of sand beneath surficial till soils.	3.3	0.54U	5.4U
EP-27 @ 10	Exploration Pit EP-27, ten feet below ground surface, sample of sand beneath surficial till soils.	4.0	0.56U	5.6U
EP-28 @ 10	Exploration Pit EP-28, ten feet below ground surface, sample of sand beneath surficial till soils.	2.2	0.52U	5.2U
G-1	Grab sample from existing vertical cut into native sands.	1.6U	0.53U	5.3U
G-2	Grab sample from existing vertical cut into native sands.	2.2	0.53U	5.3U
G-3	Grab sample from existing vertical cut into native sands.	1.6	0.53U	5.3U
G-4	Grab sample from existing vertical cut into native sands.	1.8	0.54U	5.4U
OBW-6 @ 95	Observation Well OBW-6, approximately 95 feet below ground surface, sample of sand.	1.9U	0.63U	6.3U
OBW-7 @ 270	Observation Well OBW-7, approximately 220 feet below ground surface, sample of sand.	2.4	0.67U	6.7U
	Median	3.1	na	na
	Mean	3.27	na	na
	Standard Deviation	1.29	na	na
	Puget Sound Background **	7	1	24
	MTCA Method A	200	10.0	1,000

Notes: All units are mg/kg, parts per million (ppm)

** 90th percentile levels from Ecology Publication #94-115, *Natural Background Soil Metals Concentrations in Washington State*

Modifier of U indicates that the analyte was not detected at the stated value

MTCA cleanup values shown are for industrial sites

As can be seen, all of the test results on resource samples are well within the levels believed to be background concentrations in Western Washington. Thus, arsenic, cadmium, and lead do not appear to be an issue in the sands proposed for export from the site.

Surface Soils

To determine the levels of the metals in the surface soils, a series of shallow test pits were hand excavated across the site on a 600-foot grid. Details of the field sampling are discussed in Appendix A. The test results are presented below in Table 4.

Table 4
Analytical Test Results
Surface Samples

Sample Number	Site Type	Surface			9-inch Depth			18-inch Depth		
		Arsenic	Cadmium	Lead	Arsenic	Cadmium	Lead	Arsenic	Cadmium	Lead
1**	F	330	2	830	37	0.84	27	43	0.66	19
2	F	120	2.3	390	25	1.2	10	8.7	0.56U	5.6U
3	F	150	0.79U	280	110	0.91	81	10	0.62	8.6
4	F	160	1.5	450	19	0.72	25	4.2	0.53U	5.3U
5	F?	47	0.92	54	47	0.84	59	43	0.63U	51
6	F	100	9.3	470	270	2.9	120	64	1.1	30
7	F?	17	0.58U	13	19	0.56U	18	13	0.53U	11
8	F	190	3	550	67	0.94	41	10	0.58U	7.6
9	F	98	1.6	510	110	0.95	30	9.2	0.77	7.1
10	GP	4.3	0.53U	5.3U	1.6U	0.53U	5.3U	1.6U	0.52U	5.2U
11	GP	1.9	0.53U	5.3U	1.6U	0.55U	5.5U	1.6U	0.53U	5.3U

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Table 4 (Continued)
Analytical Test Results
Surface Samples

Sample Number	Site Type	Surface			9-inch Depth			18-inch Depth		
		Arsenic	Cadmium	Lead	Arsenic	Cadmium	Lead	Arsenic	Cadmium	Lead
12	F?	6.1	0.54U	5.8	6.2	0.54U	5.4U	5.7	0.55U	6
13	F	220	1.2U	470	130	0.82	45	8.2	1.5	8.3
14	F	18	0.91	70	130	1.2	37	2.0U	0.92	36
15	GP	1.6U	0.53U	5.3U	1.6U	0.53U	5.3U	1.6U	0.53U	5.3U
16**	F	280	1.6	730	39	0.84	17	40	0.89	23
17	F	61	6	240	260	1.2	35	11	0.52U	5.2U
18	GP	11	0.59U	7.1	8.2	0.57U	5.7U	5.9	0.57U	6.1
19	F	100	6	470	270	1.4	67	3.8	0.59U	5.9U
20	F	140	5.4	710	11	0.59U	11	7.6	0.59	6.6
MTCA		200	10	1,000	200	10	1,000	200	10	1,000

Notes:

- ** Sample No. 16 is a field replicate of Sample No. 1, see Appendix A for discussion
- Site Type **F** is forested area
- Site Type **F?** is forested area but has signs of recent grading or disturbance
- Site Type **GP** is in the area of the existing gravel pit
- All units are parts per million (ppm), milligrams/kilogram
- Modifier of U indicates that the metal was not detected at the stated detection limit
- MTCA cleanup values shown are Method A for Industrial Sites
- Shaded cells exceed MTCA Method A cleanup values for industrial sites

Discussion

As can be seen in the data, two distinct trends are present in the surface samples summarized on Table 4. The first is the decreased arsenic content in disturbed areas of the Lone Star Site. The second is the decreasing levels of arsenic and lead between the upper 9 inches and the samples obtained at a depth of 18 inches. This distribution of metals is consistent with aerial deposition of the arsenic, cadmium, and lead. The arsenic and lead have become bound to the organic materials and the iron in the near-surface soils. The deposition of these materials occurred over a 70- to 80-year period of time and, as can be seen, the materials have remained largely in the upper one foot of the soil column. Where disturbed by the activities of the borrow operation, the levels of arsenic, lead, and cadmium are much lower due to either the removal of other topsoil materials and/or the incidental homogenization that has occurred with the reworking of the soils.

Leach Testing/Toxicity

Three samples with the highest concentrations of arsenic were laboratory composited and were tested using the Toxicity Characteristic Leach Procedure (TCLP). Samples S-1-0, S-8-0, and S-13-0 were chosen to be composited for the leach testing. This test is used in determining if a specific waste is a dangerous waste. The TCLP test involves the use of a liquid with a pH of 4.93 to leach the metals from the waste material. The acid used in the process is acetic acid. This test is intended to mimic the conditions that could exist in a solid waste landfill.

The composited sample was also tested using the Synthetic Precipitation Leach Procedure (SPLP) using deionized water as a leaching fluid.

In both the TCLP and the SPLP, the soil and fluid media is agitated in a tumbler for a period of 18 hours. The tumbler agitates the sample at 30 revolutions per minute. Thus the leaching procedure is not passive in nature. The results of the testing are presented below in Table 5.

Table 5
Analytical Test Results
Leach Testing of Surface Samples

Metal	Average Soil Concentration	TCLP Test Results	TCLP Dangerous Waste Criteria	SPLP Test Results
Arsenic	247 ppm	0.40U	5.0 ppm	0.21 ppm
Cadmium	2.1 ppm	0.020U	1.0 ppm	0.02U
Lead	617 ppm	0.20U	5.0 ppm	0.0092 ppm

Notes: Modifier of U indicates that the specific metal was not detected at the stated detection limit
All units are parts per million (ppm)

As can be seen, the amount of arsenic, cadmium, and lead that leach from the soils in the TCLP test are well beneath the levels that would cause the soils to be classified as a dangerous waste under this criteria. In addition, the levels of the arsenic that leach out under the SPLP testing are on the order of 0.08 percent of the original value in the soils. Thus, the three metals exhibit a low solubility in water.

The final step in determining if the topsoils are a dangerous waste is the dangerous waste criteria under WAC 173-303-100. We used the "book designation" using the assumptions discussed in the next paragraph.

No testing was done by the EPA to determine the compounds actually present in the smelter fallout. It has been assumed by the EPA that the arsenic is present in the form of arsenic trioxide. For this memo, we have assumed that the cadmium is in the form of cadmium oxide, and that the lead is in the form of lead oxide, lead sulfate, or lead sulfide. Using these compounds, the arsenic falls in Toxic Category B, and the lead and cadmium compounds fall in Toxic Category C. Using the assumed form of the metals, the topsoils are not a dangerous waste from the toxicity criteria.

Concurrence from Ecology should be obtained on the determination that the topsoil material is not a dangerous waste.

Regulatory Concerns

The following discussion is a summary of regulatory concerns. Other laws and regulations may apply to this site beyond the laws and regulations discussed and summarized in this document. The summaries below are not legal interpretations and are not legal advice. Concurrence with the specific regulatory agency is recommended on the interpretations of the laws and regulations.

Arsenic and its compounds are regulated under a wide variety of federal and state regulations. These include:

Hazardous Air Pollutants [Clean Air Act (42 USC § 7401 et seq.)] (federal). CFR 60, Subpart OOO, regulates non-metallic mineral processing plants and would potentially regulate the emissions from specific crushers or conveyer belt systems on-site. The issue of arsenic in air pollution would fall under controls for fugitive dust that would be regulated by the local air pollution control agency.

Hazardous Constituents [Resource Conservation and Recovery Act, (as amended, 42 USC § 321 et seq.)] (federal). The Resource Conservation and Recovery Act defines hazardous waste and regulates the management of hazardous wastes. If the soil was classified a dangerous waste under Washington State laws, appropriate paperwork for management and ultimate disposal of the soils from the site would be required.

Hazardous Substances [CERLA-SARA(Superfund) 40 USC § 9601 et seq.] (federal). The Superfund regulations required the cleanup of the ASARCO smelter and the adjacent residential areas that were impacted by the aerial fallout from the smelter. The limits of the Superfund cleanup area did not include the southern end of Vashon or Maury Island. The EPA reviewed the prior sampling in the Pathways Study and determined that the southern end of Vashon and Maury Islands did not require action under the Superfund regulations.

Maximum Contaminant Levels [Safe Drinking Water Act (43 USC § 300f et seq.)] (federal). The Safe Drinking Water Act primarily regulates the operation of water suppliers and sets uniform water quality limits for drinking water. The Safe Drinking Water Act does not directly effect the issue of arsenic, cadmium, and lead in the topsoils of the Lone Star property.

Clean Water Act (33 USC §121 et seq.) (federal). The Clean Water Act regulates the discharge of pollutants into the waters of the United States. At the Lone Star Site, the Clean Water Act will cover site activities through the National Pollution Discharge Elimination System. The site is required to have an NPDES permit.

Toxic Release Inventory Chemicals [Emergency Planning and Community Right to Know Act (42 USC § 11011 et seq.)] (federal). This system requires certain manufactures, processors, and other companies to file an annual form that details all releases of 650 listed chemicals to air, water, or land. Arsenic is a listed chemical. The proposed Lone Star operation will fall under Standard Industrial Classification (SIC) codes of 1429, 1442, 1446, or 1449. None of the SIC codes in the 1400 range are required to report releases under the Toxic Release Inventory. Thus, this regulation will not affect the issue of arsenic, cadmium, and lead in the topsoils of the Lone Star property.

Model Toxics Control Act (state). Chapter 173-340 WAC. With the presence of arsenic above the Method A cleanup values for Industrial Sites, it is possible that the site and presence of arsenic will be regulated under MTCA. However, the levels of arsenic, lead, and cadmium are expected to be an area-wide issue. The proponent, Lone Star, is discussing the issues of arsenic, cadmium, and lead in the topsoils on the site with Ecology. Transport of the topsoil materials off-site would bring MTCA into effect on this issue.

Dangerous Waste Regulations (state). Chapter 173-303 WAC. Based on the results of TCLP testing and the toxicity of the constituents, the contaminated soils are not a dangerous waste as defined by the Washington State Dangerous Waste regulations. The topsoil could be disposed of into the municipal waste stream and would not require disposal into a hazardous waste landfill.

Washington Clean Air Act (state). Chapter 173-400 WAC does not directly regulate operations such as non-metal mining. In addition, the issue of arsenic in the topsoils on the Lone Star Site is not specifically discussed. However, under WAC173-400-040 General Standards of Maximum Emissions, it clearly discusses off-site deposition of fallout, the issue of fugitive dust, and that no person shall cause or permit the emission of any air contamination from any source if it is detrimental to the health, safety, or welfare of any person, or will cause damage to property or business.

Puget Sound Air Pollution Control Agency, (PSAPCA), Regulation 1. Dust controls will be required as required by Sections 9.15 and 9.2 of Regulation 1. The use of Best Available Control Technology (BACT) will be required to comply with the regulations. For this site, this would likely consist of the addition of water to keep the soil moist to avoid excessive dust. The issue of arsenic in the topsoil is not specifically addressed.

Water Quality Standards RCW 90.48 and 90.54. (state). These laws and regulations control activities that would degrade the surface or groundwater of the State of Washington. Thus, these two laws apply to the extent that there is a concern that ground or surface water degradation could occur as a result of disturbing the topsoils with the elevated arsenic levels.

Industrial Safety (Safety Standards for General Occupational Health) Chapter 292-62 WAC. This law regulates the training and communication of employees concerning hazards. Arsenic is specifically addresses in WAC 296-62-07347. Specific requirements including exposure monitoring and methods of compliance are addressed. An action level is set at five $\mu\text{g}/\text{m}^3$ averaged over an eight hour period. Monitoring is required to determine if this action level is exceeded. Additional requirements for respirator protection become effective above the action level.

Possible Impacts

Four pathways for environmental impacts have been identified: redistribution through dust; redistribution through erosion and redeposition; direct contact with the impacted soils; and impacts to the groundwater by dissolving the metals and transporting them to the groundwater.

If grading on-site was to be done in an uncontrolled manner, the arsenic, cadmium, and lead present in the topsoil could be released as air and water pollution during site stripping and reclamation activities. The remobilization of the constituents would take place as dust in the air and as sediment in surface water runoff from the site. The dust would impact the population that lives in the vicinity of the sand and gravel pit through increased dust available for direct inhalation both in the outdoor environment and inside the individual houses and buildings. The mobilization of arsenic in sediment could impact water and sediment quality in Puget Sound.

While the arsenic, lead, and cadmium exhibit low solubility, placement of these materials in direct contact with groundwater could create degradation of the groundwater on the site that could migrate to off-site locations or into Puget Sound.

Possible Mitigation

This discussion presents an overview of possible mitigation to reduce or minimize impacts to the site and environment due to the presence of elevated arsenic and lead on the site. Other options are possible. Discussions with regulatory agencies are underway by the proponent, Lone Star Industries. We expect that additional soil samples will be taken during site development activities to verify that the impacted soils have been adequately segregated. In addition, monitoring wells have been constructed on-site to allow for direct sampling and analysis of groundwater from the Lone Star property.

Erosion

Through the use of common best management practices and phased excavation, the potential for erosion and transport of the impacted soils can be reduced. The use of silt fences, suitable revegetation of disturbed soils, and straw bales can control materials that do become available for transport. Thus, common best management practices that are currently planned for site activities should be sufficient to control the risk of impacted soils being transported through erosion. Accumulated silts in sediment management facilities could either be assumed to contain heavy metals and be managed accordingly, or could be tested and treated according to individual test results.

Direct Contact

Health impacts from the arsenic, cadmium, and lead to individuals are believed to consist primarily of ingestion or inhalation. As discussed in the Pathways Study, and in documents prepared for the EPA for the ASARCO project, the population believed to be at greatest risk is children. This is due to their smaller size, which increases the proportional dosage, along with the propensity for younger children to place their hands into their mouths. The chances for direct contact could be controlled by fencing or otherwise restricting access to the portions of the site where the topsoils are stockpiled or otherwise present. Alternatively, the impacted soils could be provided with a cover of clean soils to prevent direct contact with workers or other persons on-site.

Dust

Direct inhalation could occur as a result of dust being remobilized on-site and being transported to an off-site source. The potential for this can be reduced by limiting the work involving the impacted topsoils to periods of high soil moisture content or the use of water applied at a rate sufficient to wet the particles down. Disturbed soils should be restabilized with suitable engineering controls or vegetation as soon as possible.

Workers on-site will need to have sufficient training and safety equipment to control their potential exposure to the heavy metals during site clearing and restoration activities. Lone Star will need to address worker safety and training for this project. Exposure monitoring will need to be done during topsoil management activities to determine if the action level is reached or exceeded. If the action level of five $\mu\text{g}/\text{m}^3$ averaged over an eight-hour period is exceeded, additional engineering controls and worker protection will be required by state law.

Dust controls will be needed as required by Sections 9.15 and 9.2 of PSAPCA Regulation 1. The use of Best Available Control Technology (BACT) will be required to comply with the regulations. For this site, this would likely consist of the addition of water to keep the soil moist to avoid excessive dust. Other options may be used if they qualify as BACT.

Groundwater Impacts

During the topsoil stripping operations, impacts to the groundwater can be reduced by stockpiling the impacted topsoil as far above the groundwater table as possible. Placement of the topsoils in direct contact with the groundwater should be avoided. Groundwater monitoring should be performed to document actual groundwater quality conditions. The proponent is discussing options for final placement of the impacted topsoils with Ecology.

Long-Term Mitigation

Option 1 Removal and Off-Site Disposal of the Soil

Based on the results of testing done on selected site soils, the impacted soils could be excavated and removed from the site for off-site disposal. It is possible that the soils could be disposed of into the King County Municipal Waste Stream. Discussions with King County would be required to determine the feasibility of this option. It is possible that the soils could be disposed of at a facility within the boundaries of the former ASARCO facility in Ruston. Other disposal sites also exist off the island for lawful disposal of the topsoil materials. This option essentially eliminates long-term site impacts due to the fallout-impacted topsoil on the site.

Option 2 On-Site Entombment

The topsoils with the elevated levels of arsenic and lead could be concentrated at a portion of the site where they could be buried. In addition, due to concerns regarding the groundwater, the affected soils should not be disposed of in close proximity to the static water levels. Hence, the soils would require that a portion of the site not be borrowed down to minimum planned elevations to allow the separation of the affected soils from both the groundwater and the surface. A deed restriction would be needed to disclose the presence of the entombed materials and to control/limit future access to the materials. Monitoring of groundwater on-site to demonstrate adequate isolation of the heavy metals from the groundwater would be required. Administrative and engineering controls would be needed to maintain the cover over the entombed materials.

Other options are possible. We understand that the proponent is working with Ecology to determine the preferred option for topsoil management on-site.

Groundwater Impacts

The results of the testing done for the EPA and by us for this memo indicate that the heavy metals have a very low solubility in their current state. This is further demonstrated by their concentration in the upper one foot of the soil column. No significant migration of these materials appears to have occurred over the past 70 years, except in the presence of cultural disturbance. Groundwater testing on the southern portion of Vashon Island and on Maury Island has found no measurable degradation of groundwater quality with arsenic, lead, or cadmium. The metals bind readily to the organic materials in the topsoils and to iron present in the native soils. However, unless the affected soils are removed from the site for lawful off-site disposal, groundwater monitoring will need to be done to verify the condition of the groundwater. A system of groundwater quality monitoring points have been established and will be tested through the development of the pit. The distance to public drinking water supplies is large enough to allow for time to react to issues of groundwater quality that may arise. In the event contamination is found at the on-site wells as a result of the reworking of the topsoil, groundwater treatment may be required and the source of the impacts could be isolated.

Steve Hall
March 23, 1999

Closure

This memo transmits analytical test results and conceptual discussion of impacts and mitigation. The proponent is having meetings and discussions with Ecology to determine the options that are to be used on this site. Thus, final mitigation actions will likely differ from the discussions of this memo. Nothing in this memo should be construed as consisting of legal advice. The conceptual discussion of laws is to put the presence of the heavy metals in perspective. The proponent, Lone Star Industries, is discussing final site management options with the appropriate regulatory agencies.

Chuck Lie

Encl: References
 Figure 1 - Vicinity Map
 Figure 2 - Resource Sample Location Plan
 Figure 3 - Arsenic Levels
 Figure 4 - Cadmium Levels
 Figure 5 - Lead Levels
 Appendix A - Work Plan
 Appendix B - Analytical Test Reports

REFERENCES

Associated Earth Sciences, Inc, 1998. Soils, Geology, Geologic Hazards and Groundwater Report, Existing Conditions, Impacts and Mitigation, Maury Island Pit, King County, Washington, prepared for Lone Star Northwest, Inc.

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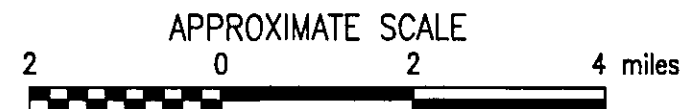
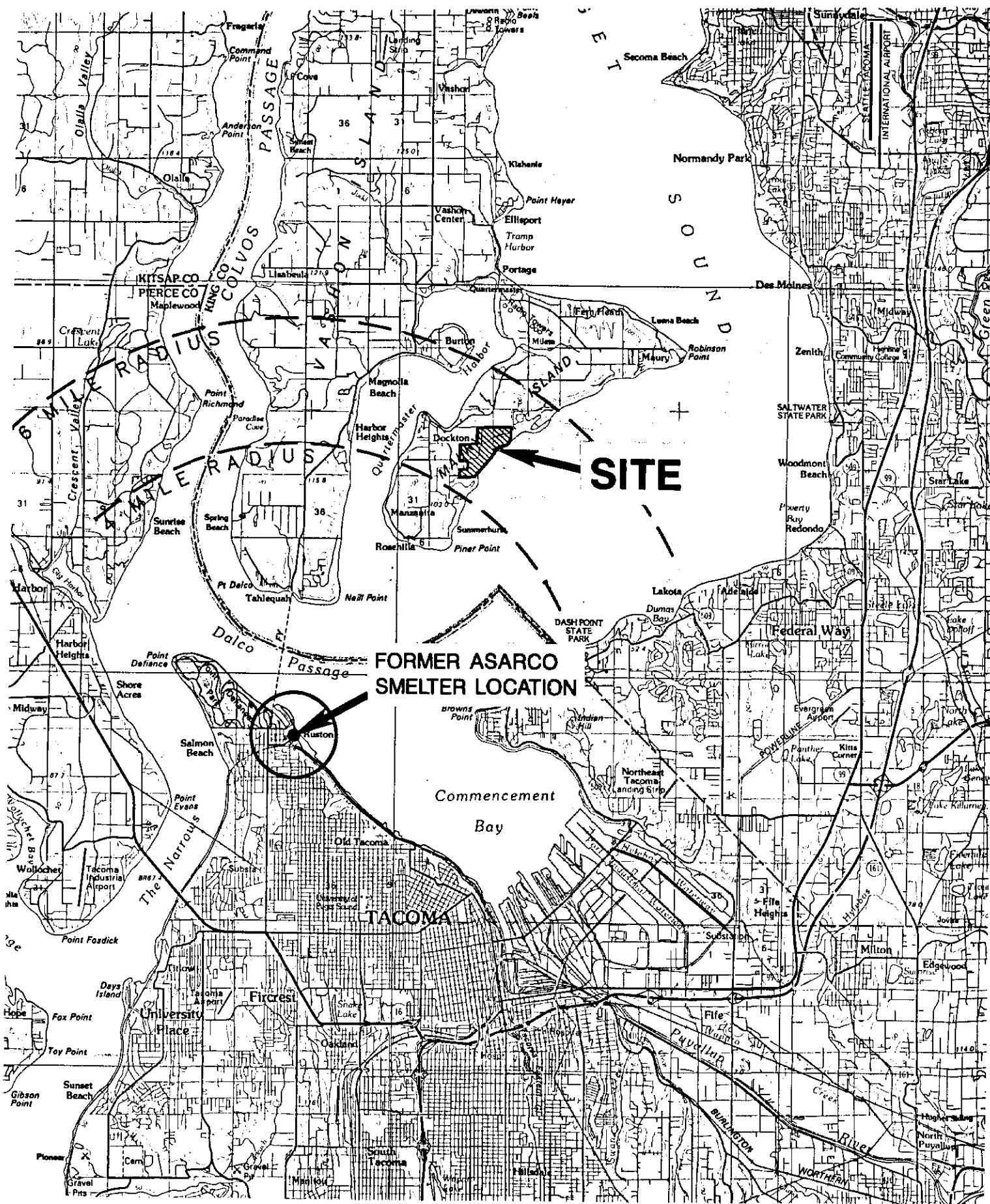
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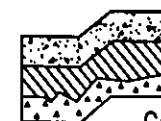
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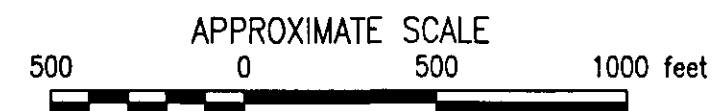
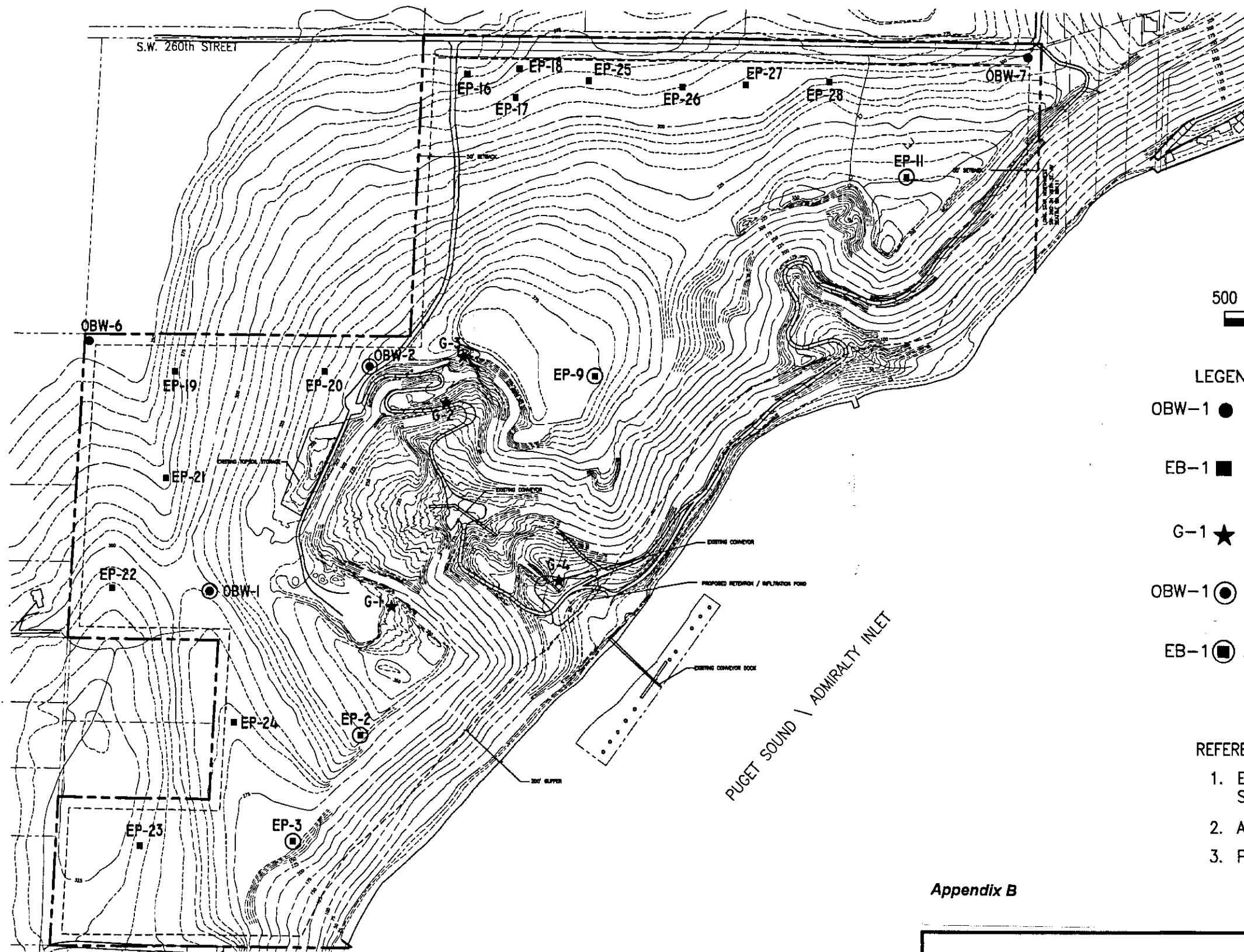
Appendix B



**TERRA
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Geotechnical Consultants

VICINITY MAP
LONE STAR GRAVEL PIT
MAURY ISLAND
KING COUNTY, WASHINGTON

Proj.No. 4169-1 Date MAR. 1999 Figure 1



LEGEND

- OBW-1 ● APPROXIMATE LOCATION OF OBSERVATION WELL SAMPLED BY TERRA ASSOCIATES
- EB-1 ■ APPROXIMATE LOCATION OF EXPLORATION PIT SAMPLED BY TERRA ASSOCIATES
- G-1 ★ APPROXIMATE LOCATION OF RESOURCE GRAB SAMPLE SAMPLE BY TERRA ASSOCIATES
- OBW-1 ⊙ APPROXIMATE LOCATION OF OBSERVATION WELL SAMPLED BY AESI
- EB-1 ⊠ APPROXIMATE LOCATION OF EXPLORATION PIT SAMPLED BY AESI

REFERENCE:

1. EXPLORATION LOCATION PLAN BY ASSOCIATED EARTH SCIENCES, INC. (AESI).
2. AERIAL MAPPING BY NIES MAPPING GROUP, INC.
3. PROPERTY LINES BY JONES, BASSI & ASSOCIATES, 10/01/70.

Appendix B



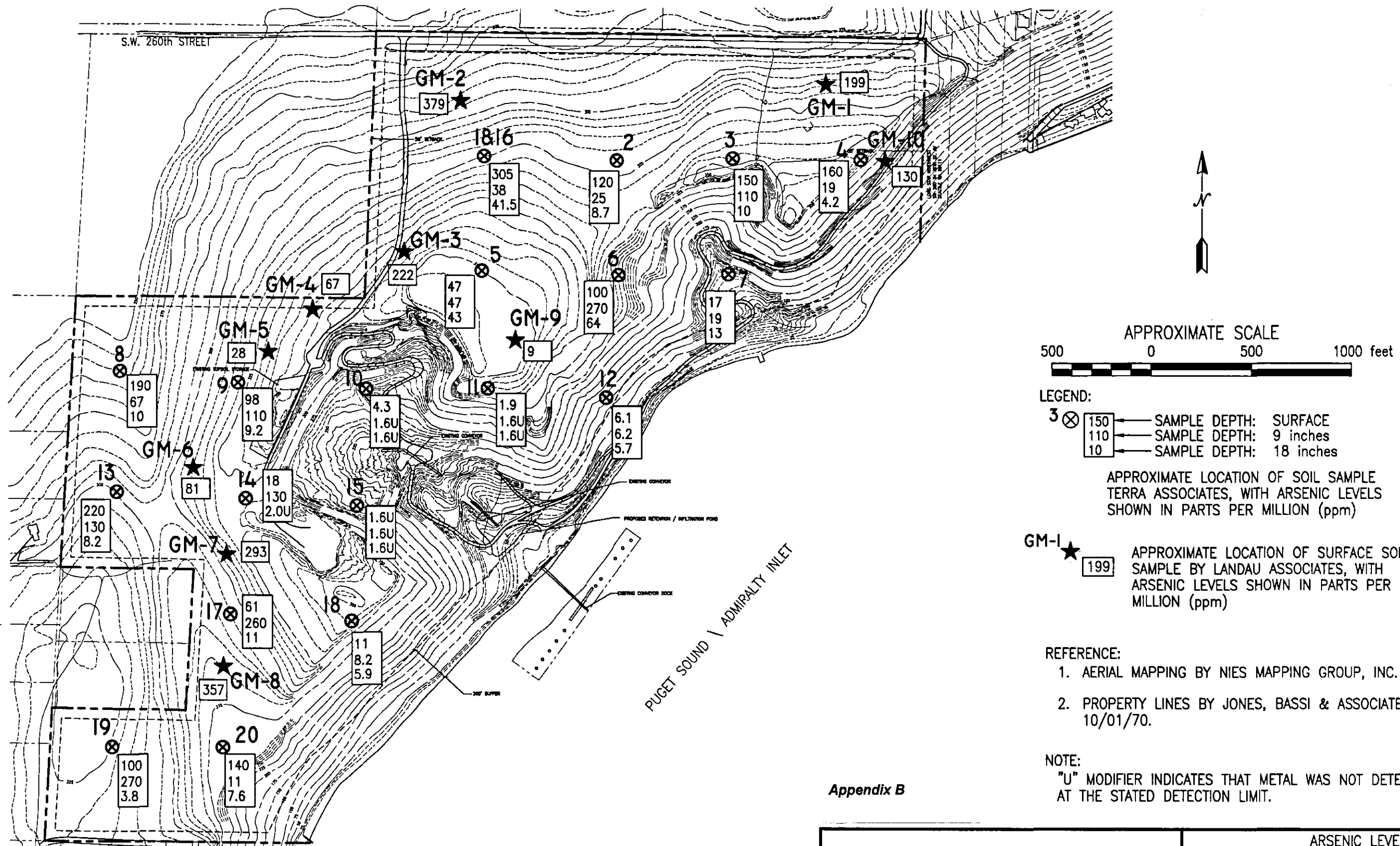
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RESOURCE SAMPLE LOCATION PLAN
LONE STAR GRAVEL PIT
MAURY ISLAND
KING COUNTY, WASHINGTON

Proj.No. 4169-1

Date MAR. 1999

Figure 2



Appendix B



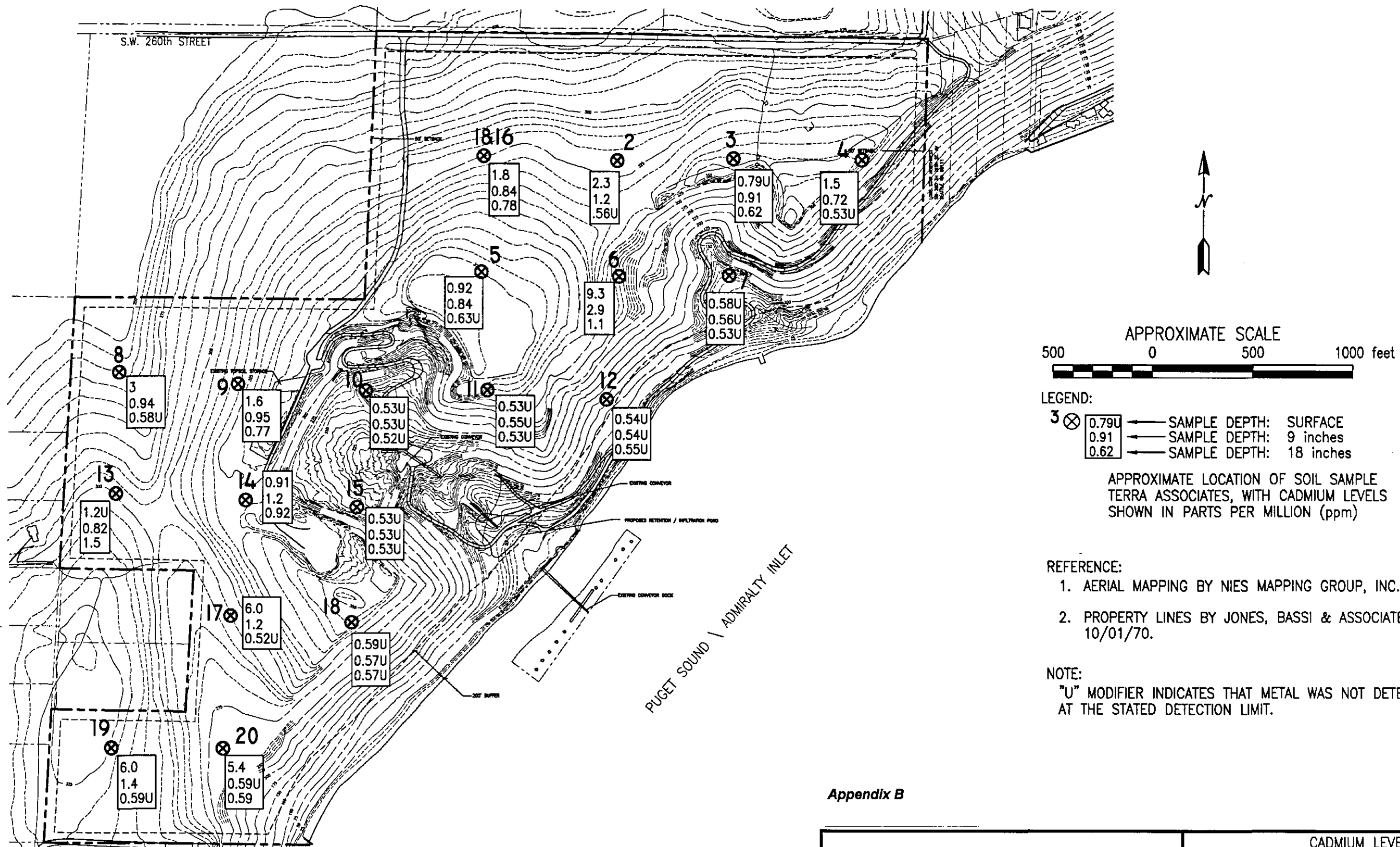
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ARSENIC LEVELS
LONE STAR GRAVEL PIT
MAURY ISLAND
KING COUNTY, WASHINGTON

Proj.No. 4169-1

Date MAR. 1999

Figure 3



Appendix B



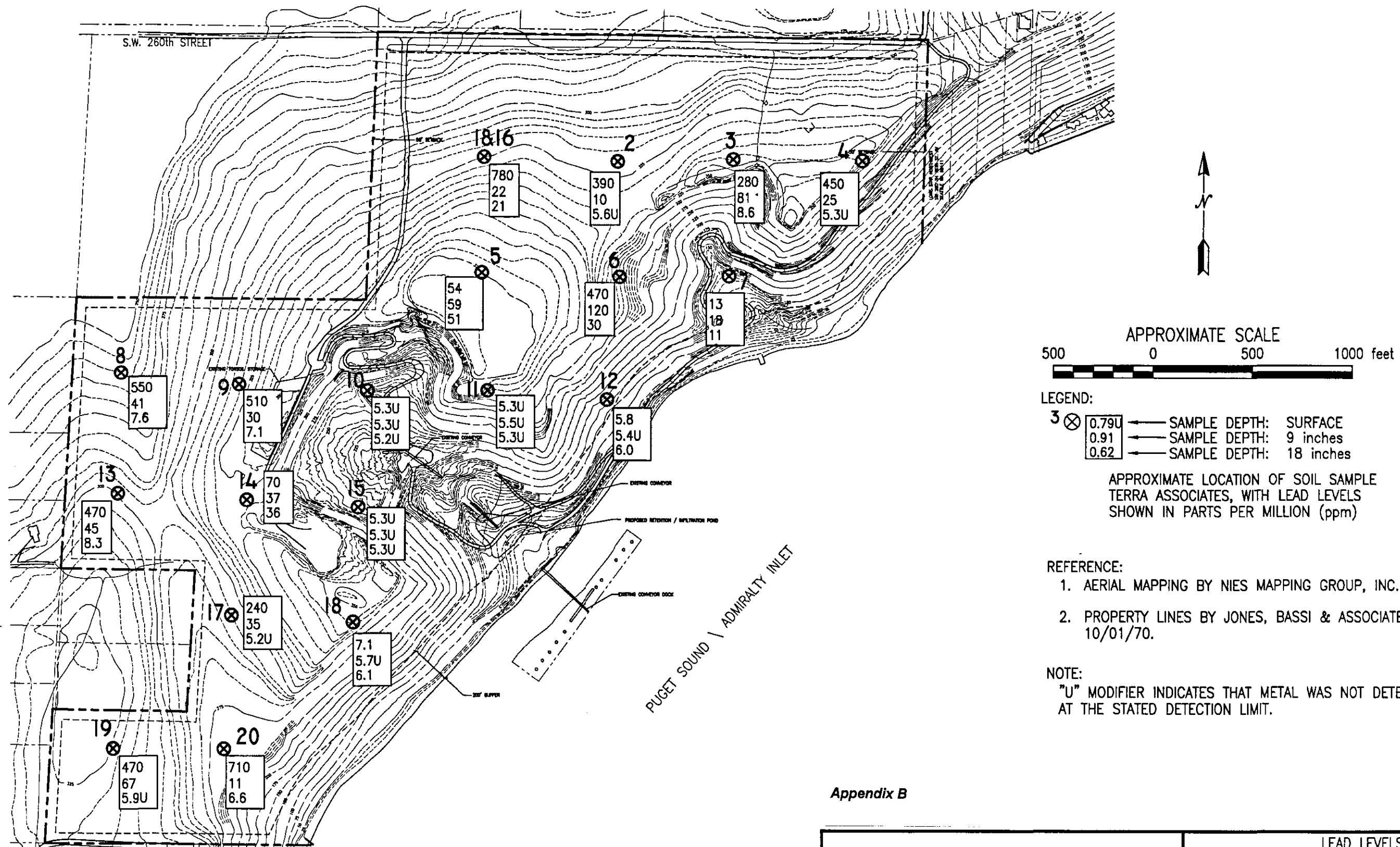
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CADMIUM LEVELS
LONE STAR GRAVEL PIT
MAURY ISLAND
KING COUNTY, WASHINGTON

Proj.No. 4169-1

Date MAR. 1999

Figure 4



Appendix B



TERRA ASSOCIATES
Geotechnical Consultants

LEAD LEVELS
LONE STAR GRAVEL PIT
MAURY ISLAND
KING COUNTY, WASHINGTON

Proj.No. 4169-1

Date MAR. 1999

Figure 5

**APPENDIX A
WORK PLAN
LONE STAR MAURY ISLAND SITE
KING COUNTY, WASHINGTON**

Terra Associates, Inc. sampling for arsenic, cadmium, and lead on the site was performed in two phases. The sample locations were determined prior to and independently of all prior sampling on this project. The first phase of sampling consisted of obtaining 20 samples intended to represent the resource present on the site. The resource present on this site consists of sand and gravel that would be sold and exported from the site.

To obtain samples of the resource, we were present during the excavation of supplemental test pits on the site during late January 1999. Samples were taken from the bucket of a backhoe. Prior to sampling, each test pit was cleaned of sloughed soil. The samples were taken from the center of the bucket to obtain samples that had not been in contact with the excavating equipment. The sample was transferred into the sample container using a stainless steel sampling tool. The depths of these samples range from 8.5 to 10.0 feet below grade.

To obtain samples deeper beneath the ground surface, two grab samples were obtained of cuttings from monitoring wells being drilled on-site. The monitoring wells were being drilled with an air rotary drill rig. Samples were obtained by placing a clean container at the discharge hose from the drilling tools.

Finally, selected grab samples were obtained from existing fresh excavations in the existing borrow pit excavation. These samples were obtained by using a small spade shovel to excavate 18 inches horizontally into an undisturbed soil face. A stainless steel sampling tool was then used to obtain the sample.

All samples obtained by Terra Associates were discrete samples; no field compositing was performed.

The locations of the test pits and monitoring wells were provided to Terra Associates by Associated Earth Sciences, Inc. The locations of the grab samples were determined by using topographic features shown on the site topography plan.

The second phase of sampling consisted of obtaining 60 near-surface soil samples from across the site. To choose sample locations, a grid was superimposed on the site such that 20 sample points would exist within the area of the proposed borrow pit operation. This was accomplished by drawing a 600 foot by 600 foot grid on the site. The sample points were numbered 1 through 20. At random, one sample point was chosen and eliminated. The randomly chosen sample point was Sample No. 16. Sample No. 16 was obtained as a field duplicate of Sample No. 1. The purpose of the field duplicate is to provide a quality control review of the laboratory procedures.

APPENDIX A (Continued)
WORK PLAN
LONE STAR MAURY ISLAND SITE
KING COUNTY, WASHINGTON

At each sample location point, the sampling consisted of a surface sample, a sample at 9 inches in depth, and a sample at 18 inches in depth. The surface samples were obtained by removing existing leaf and branch litter from the sample location. A disposable plastic spoon was then used to obtain a sample in the upper two inches of the soil column.

A shovel was used to advance the hole to a depth of approximately nine inches below the existing grade. The shovel was then rinsed thoroughly with deionized water and used to remove soil from the nine-inch depth of the excavated hole. A disposable plastic spoon was then used to transfer the soil from the center of the mound of soil on the shovel to the sample container. The test hole was then advanced to a depth of 18 inches below grade where the same procedure used at 9 inches was repeated to obtain a sample of the soil column at a depth of 18 inches.

The locations of the sample points were determined by using a hip chain and compass to measure from known points on the site. A survey ribbon was left at each sample point.

Where stainless steel sampling tools were used, the tools were decontaminated in between samples to reduce the potential for cross contamination. This procedure consisted of washing the tools in a solution with Alconox Soap, followed by a thorough rinse in distilled water. Where disposable plastic spoons were used, each spoon was used once and then discarded.

All samples were placed into laboratory prepared glassware. Each sample was given a unique identification number and was stored in a field refrigerator pending delivery to the analytical laboratory. Chain of custody protocols were followed in sample management.

At Sample Point No. 1, each sample interval was scooped into a fresh zip lock bag and homogenized prior to being transferred into the individual laboratory prepared containers. This field homogenization was to reduce variability due to the matrix of the sample. Sample No. 16 is a field duplicate of Sample No. 1.

None of the samples obtained in this phase of the work were composite samples. All samples obtained in this phase of the work were discrete samples.

At the laboratory, the samples were analyzed in accordance with EPA methods published in SW 846. To obtain lower detection limits and to reduce interference from iron in the soils, the arsenic samples were analyzed using the Gas Furnace Atomic Absorption Method, EPA Method 7060. Samples for cadmium and lead were analyzed in accordance with Ecology Method 6010 using the Inductively Coupled Plasma Technique. The samples were digested in accordance with EPA Method 3051B.

APPENDIX A (Continued)
WORK PLAN
LONE STAR MAURY ISLAND SITE
KING COUNTY, WASHINGTON

The laboratory used for this project was OnSite Environmental of Redmond, Washington. OnSite Environmental has the accreditation from Ecology to perform the tests used in this project. At the laboratory, the samples were analyzed in batches of 20. For every 20 soil samples, the laboratory performed a laboratory duplicate, a matrix spike, and a matrix spike duplicate. All quality assurance and quality control at the laboratory was performed within the body of samples obtained for this project. OnSite Environmental's quality control procedures are further detailed in their attached laboratory reports.

The results of the analysis of Sample Nos. 1 and 16 are shown below.

Sample Number	Surface			9-inch Depth			18-inch Depth		
	Arsenic	Cadmium	Lead	Arsenic	Cadmium	Lead	Arsenic	Cadmium	Lead
1	330	2	830	37	0.84	27	43	0.66	19
16	280	1.6	730	39	0.84	17	40	0.89	23
RPD	4.1	5.56	3.2	1.31	0	11.04	1.8	7.41	4.8

As can be seen, the RPD values are well beneath 20 percent, which is the upper limit of RPD chosen for this project. Our review of the laboratory QA/QC performed for this project indicates that the data is valid for the current discussion of site conditions.

APPENDIX B

ANALYTICAL TEST REPORTS

Detailed sample analysis forms are on file with King County.